From PlioMIP1 to PlioMIP2: improvements to model-proxy data comparison

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Mid-Piacenzian Warm Period aka: Mid-Pliocene Warm Period (~3.3 – 3.0 Ma)

- ~400 ppm CO$_2$ level
Mid-Piacenzian Warm Period
daka: Mid-Pliocene Warm Period (~3.3 – 3.0 Ma)

• 400 ppm CO$_2$ level

• Similar to present-day geography and topography

• Global mean $T$: 1.9-3.6°C warmer than PI (IPCC, 2013)
Canadian Arctic Environment

MPWP

Present

Rybczynski et al., 2013

http://www.tourist-destinations.com/
Amplified northern high latitude warmth

- Northern high latitude terrestrial warmth
- Northern high latitude sea surface temperatures (SST)
Arctic was likely seasonally ice free

$IP_{25}$: Ice proxy with 25 carbon atoms. Isoprenoid lipid biosynthesized by sea ice diatoms.

Comparison between ESMs and proxy records

- Pliocene Model Intercomparison Project Phase 1 (PlioMIP1)

- Underestimate northern high latitude warmth

Haywood et al., 2013
Simulated seasonal cycle of sea ice extent in PlioMIP1

Half of the coupled Earth System Models didn’t simulate seasonal ice free state.

Howell et al., 2016
From CCSM4 to CESM1.2 to CESM2

New physics:
- Closed Arctic ocean gateways
- Absence of WAIS and WGIS
- Enhanced circum-Arctic boreal forest density

Boundary conditions:
Contributions from closed Arctic ocean gateways

PlioMIP1

Closed Arctic gateways

Proxy (Pliocene – PI)

Mean absolute error = 3.95°C

Mean absolute error = 3.94°C

Arctic sea ice

Month

Ice extent (km²)

Green: PlioMIP1
Blue: new experiment
Contributions from the absence of western Antarctic ice sheet

PlioMIP1

Absence of WAIS

Mean absolute error = 3.95°C
Mean absolute error = 3.96°C

Green: PlioMIP1
Blue: new experiment
Contributions from an extensive boreal forest

![Map of ice extent](image)

**Arctic sea ice**

Green: PlioMIP1
Blue: new experiment

Mean absolute error = 3.96 °C
Mean absolute error = 3.27 °C

![Proxy vs. model plot](image)
Contributions from a greater equilibrium climate sensitivity of CESM1.2

CESM1.2 – CCSM4 (PlioMIP1)

Mean = 0.48  rmse = 1.38

Min = -16.33  Max = 8.60

\[ \Delta T_{2m} \text{ (°C)} \]

Green: PlioMIP1  
Blue: new experiment

Arctic sea ice

Mean absolute error = 3.96 °C

Mean absolute error = 3.42 °C

Proxy (Pliocene – PI)

Model (Pliocene – PI)
PlioMIP2 CESM1.2 results

Mean absolute error = 3.96°C
Mean absolute error = 3.31°C
Conclusion

• Reconstructed sea ice state and Arctic warming of the mid-Pliocene largely reflects the strength of polar climate feedbacks (including vegetation) to CO$_2$ increase with small influence from paleogeographic changes.

• Records can be informative in model selection in terms of future prediction.
Thank you!

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